

ENRICHMENT STATUS OF KAWAGAMA LAKE, HALIBURTON COUNTY

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Ministry
of the
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ENRICHMENT STATUS

OF

KAWAGAMA LAKE,

HALIBURTON COUNTY

by

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SUMMARY

Based on chlorophyll a - Secchi disc information collected during the summer of 1972, the Minden Bay area of Kawagama Lake would be considered mesotrophic or moderately productive in status. Excellent water quality characterized the remaining four study areas (Dennison, Fish Bowl, Fletcher Bay and Bear Lake) which would be defined as oligotrophic in nature. All artificial nutrients from sink and laundry wastes, including automatic dishwashers, as well as seepage from septic tank-tile field systems and garden fertilizers must not gain access to Kawagama Lake to ensure good future water quality.

In order to define clearly year to year variations in water clarity and algal conditions, a continuation of the study is recommended. Such information if maintained on a long-term basis will be extremely useful in assessing whether changes in the trophic condition of the lake are materializing.

In this regard, a suggestion is offered to continue with chlorophyll samplings and Secchi disc readings during the summers of 1974 and 1975 but, to maintain Secchi disc readings only during the years 1976 - 1978. In 1979, chlorophyll samplings would be re-introduced to complement water clarity data in order to establish whether significant changes in trophic characteristics are materializing.

INTRODUCTION

Over the past few years an increasing awareness and concern for problems of pollution in recreational lakes has materialized as a consequence of accelerated cottage development. Many individual cottagers, cottage associations and permanent shoreline residents have requested that complete water quality evaluations be carried out to assess the degree of pollution in lakes. Exhaustive physical, chemical, bacteriological and biological evaluations for a large number of lakes are beyond the financial and logistical capabilities of personnel involved in water management programmes, and in light of recent studies, are not necessary in order to categorize the quality of recreational waters. An understanding of water quality problems in recreational lakes is provided in Appendix 'A'.

In 1971, a practical but effective evaluation programme was carried out on seventeen recreational lakes in the Province of Ontario. The programme, which involved the collection of data on water clarity and algal populations, was highly successful owing to the enthusiastic efforts of local residents, cottagers, marina and resort owners, and personnel of the Ministries of Natural Resources and Environment. The success of the programme was exemplified by the fact that in 1972 the number of lakes sampled increased from seventeen to fifty-eight. This report presents the chlorophyll a - Secchi disc information from Kawagama Lake during the summer of 1972, incorporates the data into a mathematical relationship for the parameters measured and comments on the findings with a view to defining the current state of enrichment or trophic status of the lake.

METHODS

Water clarity which governs the depth of light penetration in a lake is one of the most important parameters used in defining water quality and can be measured using a Secchi disc. The disc is divided into black and white alternating quadrants and is lowered into the water on a graduated line until the quadrants cannot be distinguished. The depth at which the disc just disappears is termed the Secchi disc depth. As depicted in Figure 1, Secchi disc depths are substantially greater in lakes having low phytoplankton (microscopic free-floating algae) numbers than in lakes characterized by high algal densities and excessive vascular aquatic plant growths. Secchi disc readings were taken on eleven occasions between July 13 and October 9, 1972 at a single deep-water sampling site. Usually, two readings per visit were obtained; a mean of two readings was recorded as the Secchi disc depth.

Chlorophyll a is the amount of photosynthetic green pigment in algae and its concentrations can be used as a rough indication of the extent of biological activity in a lake at the time of sampling since it is regulated by all of the combined physical, chemical and biological factors which govern algal production. Chlorophyll samples were taken on each visit to the lake by lowering a 32-ounce bottle provided with a restricted opening to the approximate location of the 1% incident light level or zone of effective algal production. This zone was determined as twice the Secchi disc depth. The samples were immediately preserved with 10-15 drops of a 2% magnesium carbonate solution and transported to the Ministry of the Environment laboratory located in Toronto at Highway 401 and Islington Avenue. Following filtration using 1.2 micron (u) Millipore filters and extraction, the samples were analyzed by staff of the Ministry's Chemistry I Section.

The "Secchi Disc Reading" is obtained by averaging the depth at which a 23cm (9") dia. black and white plate, lowered into the lake just disappears from view and the depth where it reappears as it is pulled up.

Most of the free-floating algae are suspended in the illuminated region between the lake surface and 2 times the Secchi disc reading.

Clear, algae-free lake:
Secchi disc readings tend to be greater than 3m (9 feet).

Turbid or algae-rich lake:
Secchi disc readings tend to be less than 3m (9 feet).

Secchi Disc Reading

2 times Secchi disc reading

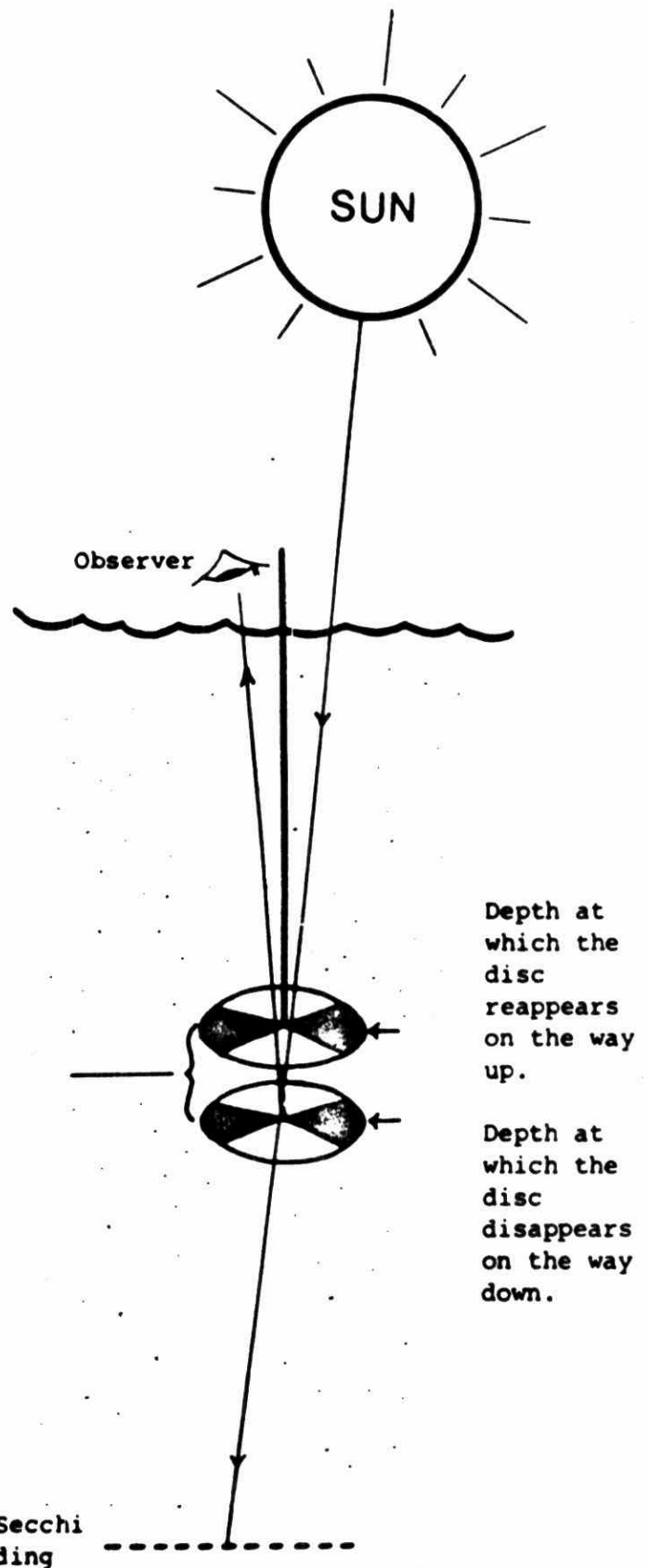


FIGURE 1: DIAGRAM ILLUSTRATING THE USE OF A SECCHI DISC TO MEASURE WATER CLARITY

DISCUSSION OF RESULTS

The chlorophyll a concentrations and Secchi disc values collected from Kawagama Lake are presented in Table 1. Secchi disc readings were lowest in Minden Bay where a yearly mean of 4.4 meters* (m) was obtained and highest at the Fish Bowl stations (7.4m). Recent evidence from in-depth studies carried out in Lakes Joseph, Rosseau and Muskoka in the Muskoka Lakes area of the province suggests that lakes having Secchi disc readings less than 3m are eutrophic or enriched in nature while those exceeding 5m are oligotrophic or unenriched in status. Lakes having Secchi disc recordings between 3 and 5m would be mesotrophic or moderately productive; that is, they have a moderate supply of nutrients, plant growths and biological production. On the basis of these guidelines alone, Minden Bay would be considered mesotrophic, whereas, the other four stations would be oligotrophic.

For the most part, chlorophyll a concentrations were low; Minden Bay exhibited the highest value (8.6 micrograms per litre - $\mu\text{g/l}$) on September 17. Experience has indicated that concentrations between 0 and 3 $\mu\text{g/l}$ (on a yearly mean) are low and reflect low to moderate algal densities. Concentrations between 3 and 6, although moderately high, may be considered acceptable for most water-oriented recreational pursuits. Levels exceeding 6 $\mu\text{g/l}$ on a yearly average indicate high algal densities. At these higher levels deterioration of water quality for recreational activities such as swimming and water-skiing may be expected, as well as a reduction in the lake's aesthetic quality. As indicated in Table 1, water quality impairment owing to troublesome chlorophyll a concentrations was generally not encountered in Kawagama Lake although moderately high concentrations did occur at the Minden Bay station.

As pointed out earlier, chlorophyll a measures the amount of photosynthetic green pigment in algae while water clarity, which is one of the most important parameters used in defining the trophic condition of a lake, is determined by means of a Secchi disc. Personnel of the Biology Section have

* Multiply meters (m) by 3.28 to obtain feet.

Table 1: Secchi disc (meters) and chlorophyll a (micrograms per litre) data collected from Kawagama Lake during 1972.

Station	Date	Secchi Disc (meters)*	Chlorophyll <u>a</u> (micrograms per litre)
Minden Bay	July 13	4.2	4.6
	16	5.4	4.8
	23	5.2	2.4
	30	5.8	2.7
	August 7	5.4	4.7
	28	5.2	2.1
	September 2	3.3	2.0
	17	3.6	8.6
	24	3.6	3.9
	October 1	3.9	1.4
	9	3.3	1.3
	Mean	4.4	3.5
Dennison	July 13	7.9	1.0
	16	8.8	0.7
	23	5.2	1.1
	30	5.8	1.4
	August 7	6.1	1.7
	28	6.1	<1.0
	September 2	8.2	<1.0
	17	5.8	2.0
	24	8.2	<1.0
	October 1	8.8	<1.0
	9	7.6	1.2
	Mean	7.1	1.2

* Multiply meters by 3.28 to obtain feet.

Table 1: Continued

Station	Date	Secchi Disc (meters)	Chlorophyll a (micrograms per litre)
Fish Bowl	July 13	8.8	0.8
	16	8.8	0.7
	23	6.7	<1.0
	30	6.7	1.0
	August 7	5.8	1.5
	28	7.0	<1.0
	September 2	7.3	<1.0
	17	6.1	<1.0
	24	8.5	<1.0
	October 1	7.9	<1.0
	9	7.6	<1.0
	Mean	7.4	1.0
Fletcher Bay	July 13	6.1	1.2
	16	6.1	0.7
	23	4.8	1.4
	30	5.4	1.8
	August 7	4.5	1.6
	28	4.5	1.7
	September 2	5.8	2.0
	17	6.1	3.0
	24	6.1	1.3
	October 1	6.1	<1.0
	9	5.4	<1.0
	Mean	5.5	1.5

Table 1: Continued

Station	Date	Secchi Disc (meters)	Chlorophyll a) (micrograms per litre)
Bear Lake	July 13	5.2	1.1
	16	5.4	0.9
	23	4.2	1.3
	30	4.8	1.2
	August 7	5.2	2.0
	28	4.8	1.7
	September 2	4.5	1.5
	17	5.8	<1.0
	24	6.1	1.2
	October 1	6.4	<1.0
	9	5.2	<1.0
	Mean	5.2	1.3

noted that a near-hyperbolic relationship exists between chlorophyll a concentrations and Secchi disc readings for many Ontario lakes. Figure 2 describes this relationship for 945 sets of data collected from approximately sixty lakes in the province. Points for eutrophic or highly enriched lakes are characterized by high chlorophyll a concentrations and poor water clarity and are situated along the vertical axis of the hyperbola while oligotrophic waters which have low chlorophyll a levels and allow significant light penetration lie along the horizontal limb. Data for mesotrophic lakes would be dispersed about the middle section of the curve. Chlorophyll a and Secchi disc data for Minden Bay are positioned in close proximity to Canning, Moore's and Cameron Lakes - three mesotrophic or moderately productive lakes. Fletcher Bay, Bear Lake, Dennison and Fish Bowl are situated in the oligotrophic portion of the curve. Significantly, all five stations are well-removed from the Bay of Quinte, Riley Lake, the Western Basin of Lake Erie and Gravenhurst Bay - four extremely enriched or eutrophic bodies of water.

In light of the aforementioned data which indicate the current "early-eutrophic" status of the Minden Bay area, all artificial nutrients from sink and laundry wastes, including automatic dishwashers, as well as seepage from septic tank-tile field systems and garden fertilizers must not gain access to the lake to ensure good future water quality.

Chlorophyll and Secchi disc data are most significant if collected on a long-term basis so that year to year variations in water clarity and algal conditions can be defined. Such information would be extremely useful in assessing whether or not changes in the trophic condition of the lake are materializing. With respect to future efforts on Kawagama Lake, it is suggested that chlorophyll and Secchi disc measurements be maintained for a period of two years to establish clearly the trophic status of the system in

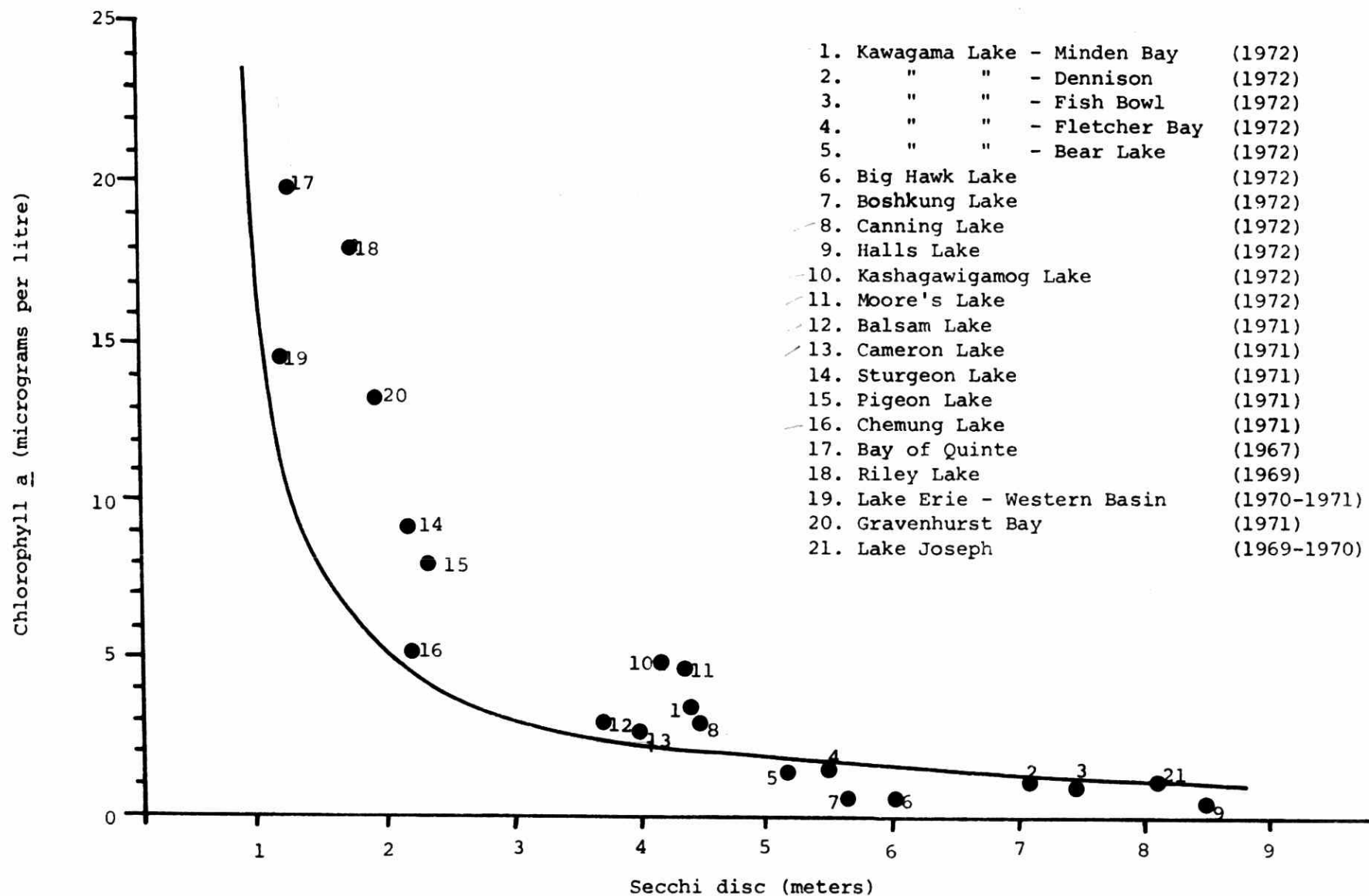


Figure 2: The relationship between chlorophyll a and Secchi disc for five locations in Kawagama Lake. Values are based on mean values collected during the summer of 1972. Also, information from a number of other lakes is included as an indication of the relative status of lakes in the study area.

relation to year to year variations. Sampling for chlorophyll would then be discontinued for a three or four year period (i.e. 1974 - 1976). However, during these years shoreline residents and/or cottagers would maintain the Secchi disc readings. Collections for chlorophyll would then be re-instated (i.e. 1977 - 1979) to complement water clarity information in order to establish whether significant changes are materializing.

Subsequently, it is recommended that cottagers consider continuing with the chlorophyll samplings and Secchi disc readings for two additional seasons during the ice-free periods and then maintaining Secchi disc measurements as per the aforementioned suggestion.

APPENDIX A

WATER QUALITY IN RECREATIONAL LAKES

Bacteriological Water Quality

For many years, cottagers have generally equated water quality with the presence or absence of coliform or fecal coliform bacteria in the water. Certainly, localized bacteriological problems in recreational lakes associated with inadequate or malfunctioning cottage waste treatment systems are still all too frequent.

In June 1970, the Ontario Water Resources Commission (now within the Ministry of the Environment) implemented changes in the criteria for bacteriological quality of water. Under these criteria, water used for total body contact recreational activities is impaired when the coliform, fecal coliform and/or enterococcus geometric mean densities exceed 1,000, 100 and/or 20 per 100 ml, respectively, in a series of at least ten samples per month, including samples collected during weekend periods (OWRC 1970).

Separate criteria are in force for private water supplies for individual dwellings and cottages. The raw water must be of such quality that it can be used with a minimum of treatment, limited to disinfection, filtration and/or softening. Microbiological criteria for private water supplies is provided in Table 1 of the Appendix.

Although bacteriological contamination is undoubtedly of most direct significance to cottagers, this type of pollution can be readily identified and through the implementation of effective controls, a rapid return to satisfactory water quality can be achieved.

Eutrophication

It is only within recent years that the more lasting effects of a type of pollution best described as nutrient enrichment have become clearly recognized. This process, scientifically known as EUTROPHICATION, is associated with sedimentation and increases in the dissolved mineral content of a lake - specifically, substances such as phosphates, nitrates, carbonates and numerous trace elements - increases which occur as a result of rainfall,

Table 1: Microbiological criteria for private water supplies

Micro-organisms		Permissible Criteria		Desirable Criteria
		Chlorination only	Chlorination and Filtration	No Treatment
Coliforms	(35°C)	100/100 ml	400/100 ml	0/100 ml
Fecal Coliforms	(44.5°C)	10/100 ml	40/100 ml	0/100 ml
Enterococci	(35°C)	1/100 ml	4/100 ml	0/100 ml
Total Bacteria	(20°C)	1,000/100 ml	4,000/100 ml	10/100 ml
Clostridia (in water)	(35°C)	0/100 ml	4/100 ml	0/100 ml

Raw water samples should be collected at least monthly. The Geometric Mean of sample results should not exceed the values given in the table above.

land runoff and percolation of soil-water to the lake. Higher concentrations of these dissolved materials cause the water to become progressively more fertile and productive, stimulating the development of free-floating microscopic plants called phytoplankton - generally referred to as algae.

Algae are normal inhabitants of virtually all surface waters and fulfill an essential role in maintaining a balanced condition in the aquatic environment. They not only provide the entire nutritional base for a complex aquatic food web which includes the production of game and commercial fish species, but produce and release oxygen to the water which is vital to the metabolism of fish and all other forms of aquatic life.

The natural development of algae is regulated not only by nutritional factors, as previously mentioned, but by environmental factors such as temperature, the intensity and duration of illumination (sunlight) and by physical factors such as size, depth and shape of the lake bottom. Thus, the corresponding rates of eutrophication in different lakes are determined by varying combinations of extrinsic and intrinsic features.

All lakes, even the largest and deepest, are transitory bodies of water and are continually undergoing a gradual process of change from youth to maturity to old age, or in limnological terms, from oligotrophy to mesotrophy to eutrophy. Progressing even further, death of a lake can be equated to the onset of a "swamp" or "marsh" condition. In small, shallow lakes, this entire process may have occurred in some cases within a single century following the glacial retreat; in other instances, the process is well advanced, and still going on, and in many larger, deeper lakes remote from human influences, significant changes can only be measured on a geologic time scale (i.e. thousands of millions of years).

Major differences in Ontario Lakes

Lakes surrounded by granitic bedrock and the sparse infertile soils of the Precambrian Shield which covers Muskoka, Haliburton and areas further north are characterized by low rates of algal production and consequently age less than lakes surrounded by the deeper, richer soils of Southern Ontario. Correspondingly, "nutrient-poor" lakes on the "Shield" having moderate to extreme depths, generally support a relatively low production of cold-water

species such as lake trout, whitefish and herring. Such lakes are characteristically clear and well-suited to swimming and other water-oriented recreational pursuits. Also, the deeper waters are well-supplied with oxygen throughout the year. This latter condition relates to the low algal production and concomitant lack of any significant oxygen depletion associated with the decomposition of algae at the lake bottom.

Alternatively, fertile lakes, such as the Kawarthas, are more turbid owing to the increased phytoplankton production and presence of suspended particulate matter. They contain substantial growth beds of submergent leafy vegetation such as water milfoil, elodea, coontail and pondweeds and produce higher yields of warm-water species such as walleye and bass.

Adequate levels of dissolved oxygen are generally present from surface to bottom since these lakes are shallow and benefit from the high level of photosynthetic activity, as well as surface aeration and complete vertical mixing during periods of windy weather. The Kawartha Lakes have been extremely productive for many years and can be considered as naturally eutrophic waters.

Artificial fertilization has been the overriding factor which has created different types of problems in these two major types of lakes. Enrichment studies have been carried out by personnel of the Ministry of the Environment at the request of concerned cottagers on lakes in northern and central Ontario such as Little Panache (near Sudbury), Riley Lake (near Gravenhurst), Silver Lake (near Port Carling), Big Straggle Lake (near Bancroft) and several others which can be considered representative of most lakes on the Shield. To varying degrees, these investigations revealed the classical evidence and undesirable features of induced fertilization in these thermally stratified lakes. Affected lakes are characterized by increased phytoplankton levels, the development of high numbers of blue-green algae in late summer and reduced pH and dissolved oxygen concentrations in the deeper waters associated with the decomposition of settled algae and higher carbon dioxide, nutrient and iron levels, again particularly evident in the deeper water where reducing conditions prevail.

Associated undesirable effects of induced eutrophication in one or more of these situations were a reduction in water clarity and related impairment of the recreational and aesthetic qualities of the water, objectionable accumulations of blue-green algae along shorelines and associated malodorous conditions on decomposition, a decrease in the quality of the water for drinking and domestic purposes including clogging of water intake filters, a reduction of the area suitable for game fish owing to oxygen reduction in the deeper waters and a further reduction in fish production through elimination of desirable fish-food organisms.

In lakes like the Kawarthas, on the other hand, increased enrichment resulting from agricultural runoff, urbanization along the system and inadequate containment of cottage wastes has placed increasing stress on an already productive aquatic environment. Here, artificial nutrient inputs have intensified the production and frequency of blooms of blue-green algae and have enhanced the production of aquatic plants to the point where many activities such as swimming, water-skiing and unimpeded boating are practically impossible. Prolonged periods of hot, calm weather have periodically caused decomposition of algae and aquatic plants in isolated bays where limited water exchange has resulted in dissolved oxygen depletion and accompanying fish mortalities. Also, periodic winter kills of fish resulting from organic decomposition have been a recurring problem. It is certain that heavy densities of weeds in many areas interfere with the harvest of game fish and it is debatable whether or not existing conditions actually favour or interfere with optimum game fish production.

How the cottagers can help

In a direct way, each cottager can do his part by ensuring that his waste treatment system conforms to present standards and is operating efficiently. Neighbouring cottagers should be encouraged to do likewise and situations such as effluent ponding or surfacing, which will obviously contribute to water pollution, should be brought to the immediate attention of local public health authorities. The use of phosphate-free washing compounds is highly recommended. In past years approximately 50% of the

phosphorus contributed by human sewage was added by detergents. On August 1, 1970 federal regulations reduced the phosphate content at P_2O_5 in laundry detergents from approximately 50% to 20%. Additional regulations which were enacted on January 1, 1973, further decreased the phosphate content to 5%. Cottagers having any doubt about the possibility of nutrients reaching the lake from their treatment systems should refrain from installing automatic dishwashers which require high phosphate cleansing products (a 1970 questionnaire indicated that about 30% of the cottages in the Muskoka Lakes have automatic dishwashers). Such conveniences may contribute significant amounts of phosphorus to recreational lakes. Indeed, in most of Ontario's vacation land, lake water used by cottagers is sufficiently soft to allow for the exclusive use of soaps and soap flakes.

A significant number of cottage owners apply lawn and garden fertilizers each year to promote vigorous growth. Use of fertilizers should be restricted as much as possible and should be discontinued if they are likely to gain access to the lake through run-off.

Unless cottagers endeavour to understand the causes and consequences of artificial nutrient enrichment and eliminate offending practices and inadequate treatment systems, water quality is certain to be undermined for future generations.

GLOSSARY OF TERMS

- ALGAE - An assemblage of simple, mostly microscopic non-vascular plants containing photosynthetic pigments such as chlorophyll. Algae occur suspended in water (phytoplankton) and attached to rocks and other suitable substrates. Some algae may produce nuisance conditions when environmental parameters are suitable for prolific growth.
- CHLOROPHYLL - The photosynthetic green pigment which occurs in all algal divisions.
- EUPHOTIC ZONE - The lighted region that extends vertically from the water surface to the level at which photosynthesis fails to occur due to insufficient light penetration.
- EUTROPHIC - Waters containing advanced nutrient enrichment and characterized by a high rate of organic production.
- EUTROPHICATION - The process of becoming increasingly enriched in nutrients. It refers to the entire complex of changes which accompanies increasing nutrient enrichment. The result is the production of dense nuisance growths of algae and aquatic weeds which generally degrade water quality and render the lake unsuitable for many recreational activities.
- MESOTROPHIC - Water characterized by a moderate nutrient supply and organic production (i.e. midway between eutrophic and oligotrophic).
- OLIGOTROPHIC - Waters containing a small nutrient supply and consequently characterized by low rates of organic production.
- SECCHI DISC - A circular metal plate, 20 centimeters in diameter, the upper surface of which is divided into four equal quadrants and so painted that two quadrants directly opposite each other are painted black and the intervening ones white. The Secchi disc is used to estimate the depth of the euphotic zone.



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